ACTIVE NOISE CONTROL IN NON-DIFFUSE THREE-DIMENSIONAL ENCLOSURES WITH HIGH MODAL DENSITY: EXPERIMENTAL STUDIES

Desheng Li and Murray Hodgson
School of Occupational & Environmental Hygiene and Department of Mechanical Engineering, University of British Columbia, 3rd Floor, 2206 East Mall, Vancouver, BC, Canada, V6T 1Z3 - Email: desheng@mech.ubc.ca

1. INTRODUCTION

In the previous paper, active control of low-frequency noise in three-dimensional rooms was theoretically investigated. The simulation results showed that, through optimal design, significant sound reduction can be achieved. In this paper, the experimental studies are reported. Experiments were done with optimal and non-optimal systems in a rectangular room.

2. EXPERIMENTAL RESULTS AND ANALYSIS

The room for the experiments is 3.95 m wide (x direction), 5.3 m long (y direction), and 2.72 m high (z direction). The ceiling is treated with mineral-fiber acoustic tile. The floor is made of vinyl tiles on concrete. The walls are double-plasterboard stud construction. The Filter-x LMS controller is used. A loudspeaker is placed in the corner (0,0,0) as the noise source. It produces a 100 Hz pure tone noise. The target control area is the whole plane at 1.60m above the floor, the typical height of human ears. The measurement grid had a 0.5 m interval in the x and y directions. The reflection coefficients of the room surfaces are estimated by measuring the reverberation time, which is 0.938 for the walls, 0.99 for the floor, and 0.812 for the ceiling. The background noise from the ventilation system is around 65 dB.

An optimal 2 by 2 control system designed using the Image-GA method (Li and Hodgson, 2003) was implemented in the room. Figure 1 shows the configuration of the optimal control system. The positions for the two control loudspeakers are (2.42, 0.85, 0.91) and (1.15, 2.22, 0.54), respectively. The two error microphones are optimally placed at (2.29, 1.20, 1.60) and (1.91, 3.42, 1.60), respectively.

First, the control signals and error signals were recorded as shown in Figure 2. From this figure, one can observe that, once the control was on, the system converged very quickly and stably. The residue signals in the error microphones are background noise. However, the objective is not just to attenuate the noise at error sensor positions. To investigate the control performance in the whole target area, the sound field was measured before and after control, respectively. The results are shown in Figure 3. The horizontal and vertical axes correspond to the length and the width of the room, respectively. One can see that after control, sound reduction is achieved in most parts of the target area. The maximum sound reduction of 33.2 dB is achieved at (2.0, 3.5, 1.60), a position close to the second error microphone. The average sound reduction is 7.8 dB. It can also be observed that, at some positions where original noise is low, the noise increases. This is because that in the design, the "locally-global" control strategy (Li and Hodgson, 2003) is employed. With this control strategy, the control system will tend to attenuate noise at positions where is loud and increase noise a little bit at positions where is quiet.

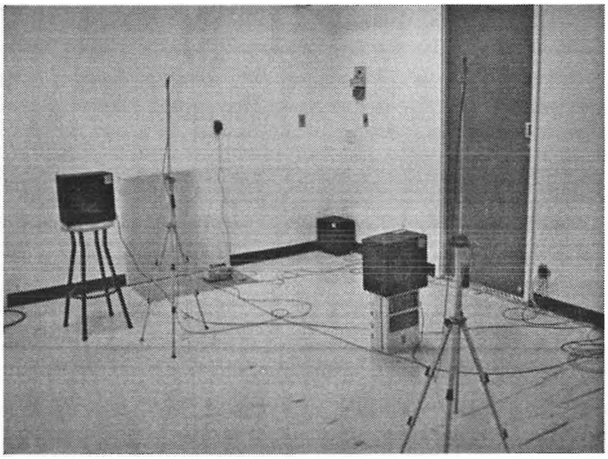


Figure 1: Configuration of the optimal control system

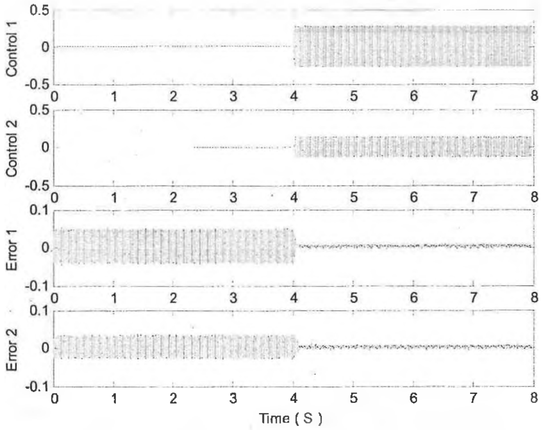
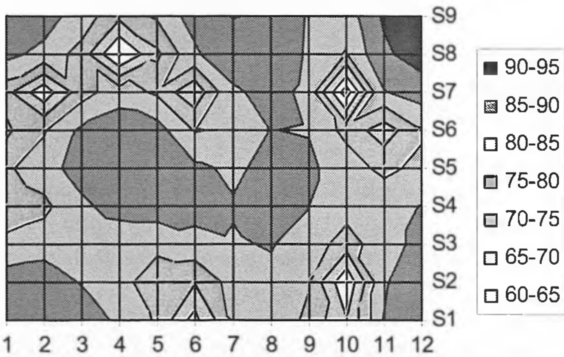
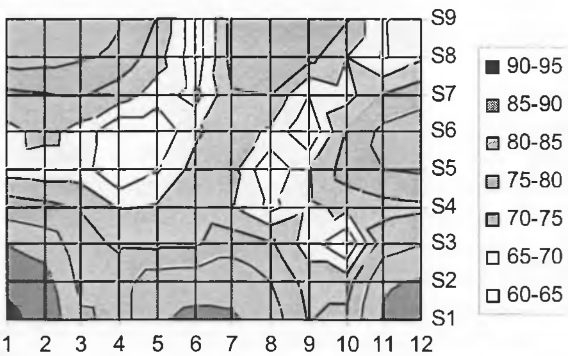


Figure 2: Control signals and error signals



(a) Before control



(b) After control

Figure 3: Sound fields before and after control

To show the effectiveness of optimal design, the experiment was also done with a randomly configured control system, which is shown in Figure 4. The positions for the two control loudspeakers are (2.15, 1.50, 0.91) and (0.75, 3.26, 0.54). The two error microphones were placed at (2.46, 2.95, 1.60) and (2.20, 4.50, 1.60).

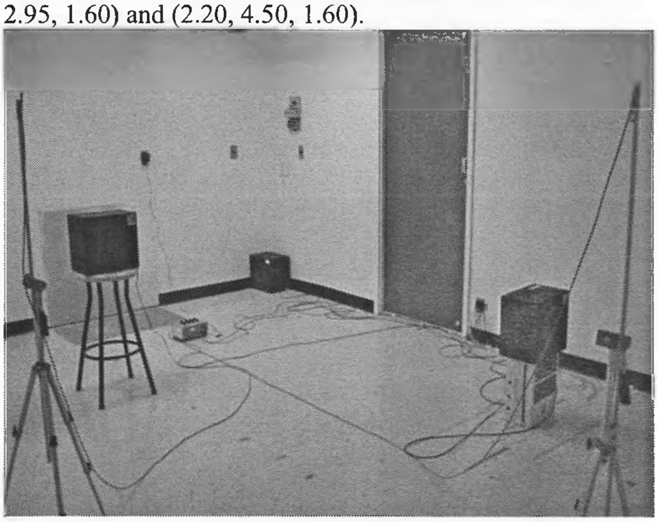


Figure 4: Randomly configured control system

Again, the noise was measured in the target area. The sound field after control is shown in Figure 5. One can observe that, with the randomly configured system, noise is increased at most positions instead of being attenuated. The average increase is 9.7 dB.

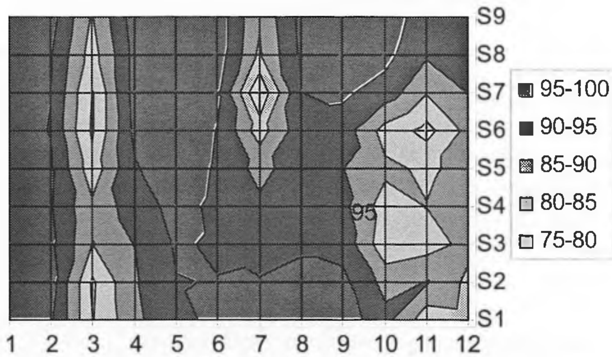


Figure 5: Sound field after control with a randomly configured control system

3. CONCLUSIONS

In this paper, the experiments were reported on active noise control in a three-dimensional room. A 2 by 2 control system was designed using the Image-GA method, and implemented. Experimental results showed that, with the optimally designed control system, significant sound reduction can be achieved even in a three-dimensional room with high modal density. To further show the effectiveness of the optimal design, a randomly configured control system was also implemented. With this system, the noise was increased instead of being attenuated. The research showed that active control technology can be used to attenuate the low-frequency noise in a three-dimensional room. But the optimal design is critical to ensure good sound reduction.

REFERENCE

Li, Desheng and Hodgson, Murray (2003) “Active noise control in non-diffuse three-dimensional enclosures with high modal density: theoretical studies”, Acoustic week in Canada, Edmonton.

ACKNOWLEDGEMENT

The work is supported by UBC Bridge Program and NIH of the United States. The authors would like to thank Mr. Haoming Qin and Mr. Tim Luu for their help in the experiment.